26 pages

IMPLICATIONS OF PRIVACY NEEDS AND INTERPERSONAL DISTANCING MECHANISMS FOR SPACE STATION DESIGN

Progress Report July - August, 1985
Submitted August 30, 1985

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AWARD: NAG 2 - 357
Amount: $9,866
Awarded: July 18, 1985
Period of Support: June 1, 1985 - December 31, 1985

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I. OVERVIEW

Privacy needs, or people's needs to regulate their degree of contact with one another, and interpersonal distancing mechanisms, which serve to satisfy these needs, are common in all cultures. Isolation, confinement, and other conditions associated with spaceflight may at once accentuate privacy needs and limit the availability of certain common interpersonal distancing mechanisms. Thus, spacefarers may find that they have too little or too much interpersonal contact. Loneliness occurs when people have less contact with one another than they desire. Crowding occurs when people have more contact with one another than they desire. Crowding, which is considered the greater threat to members of isolated and confined groups, can contribute to stress, a low quality of life, and poor performance. Drawing on the general literature on privacy, personal space, and interpersonal distancing, and on specialized literature on life aboard spacecraft and in spacecraft-analagous environments, the present study seeks to develop a quantitative model for understanding privacy, interpersonal distancing, loneliness, and crowding, and to trace the practical implications of this model for space station design.

II. AIMS

1. Exposition of current theory and research on privacy needs, personal space, interpersonal distancing, loneliness and crowding with special reference to spaceflight and spaceflight analagous conditions;

2. Development of a quantitative model for understanding privacy, interpersonal distancing, loneliness, and crowding;

3. Derivation of specific design recommendations for accommodating privacy needs aboard the space station;

4. Improving the quality of life and productivity of Space Station crews.

III. METHOD

This is a literature review and synthesis. The first step is locating potentially pertinent abstracts. The second step is assessing the relevance of these abstracts. The third step is the assembly and review of the relevant articles. The fourth step is analyzing and synthesizing this literature. The fifth step is using the analysis and synthesis as a base for a quantitative model. The sixth step is deriving specific recommendations for Space Station design.

IV. PROGRESS TO DATE

The primary method for locating the appropriate literature was through computer searches of the Psychological Abstracts. During April and May, 1985, the primary searches were performed featuring crowding, personal space, and privacy as descriptors. The results of these searches have been enhanced by additional Psychological Abstract searches on behavioral topics related to spaceflight and spaceflight - analagous environments, and by supplementary searches of the National Institute of Health abstracts and the Sociological Abstracts.

All abstracts have been read, evaluated, and classified into one of four priority categories: A = extremely important; B = important; C = potentially useful; and D = irrelevant. The articles associated with the abstracts were then collected in order of priority, with the exception that those with a "D" classification were not collected. The collection of the A, B, and C articles is essentially complete. In addition, a number of useful articles have been located through other means.

All of the A and B and a few of the C articles have been read by the PI and all pertinent articles are being re-read by at least one additional researcher. At present, the first draft of the final report is under way; the literature review is approaching completion, but the sections regarding the quantitative model and the recommendations for Space Station have yet to be drafted. However, we do include some of our ideas about the undrafted sections in this progress report.

IMPLICATIONS OF PRIVACY NEEDS AND INTERPERSONAL DISTANCING MECHANISMS FOR SPACE STATION DESIGN

In this section, we present a brief overview of the likely organization and content of the final report. We include major theme sentences to provide the reader with a better overview of organization and coverage than would be easily obtained from a standard skeletal outline. It should be emphasized, however, that outline is still provisional, and that whereas we do have a sense of direction for both the quantitative model and the recommendations for the Space Station, considerable refinement remains to be done.

I. INTRODUCTION

In the introduction, we consider the general literature on privacy, interpersonal distancing, loneliness, and crowding in everyday, spaceflight - analagous, and spaceflight environments. We find that people in each of these environments have needs to regulate theirs contact with one another, and that the failure to achieve the desired degree of contact produces generally adverse effects on mood, morale, and performance.

A. PRIVACY

Privacy, which we define in terms of level of social contact, has two components. One is exposure, or the extent to which a given person is available to (or subject to contact by) other people, and the other is accessibility, or the extent to which other people are available (or subject to contact by) that person. People in all known cultures seek to regulate both their exposure to other people and other people's accessibility to themselves.

At any one point in time, there are achieved and desired levels of privacy. . Loneliness refers to conditions under which the achieved level of contact is less than the desired level of contact. Crowding refers to conditions under which the achieved level of contact is greater than the desired level of contact. A discrepancy between these two levels prompts interpersonal distancing behaviors which are intended to bring the two levels into alignment.

1. Functions of Privacy

Limiting contact with other people serves three important functions. First, reducing exposure and accessibility reduces demands on a person's attention, thereby allowing him or her to concentrate on other matters, or providing "down time" for "rest and recuperation." Increasing exposure and accessibility, on the other hand, increases activation or arousal, oftentimes beyond those levels that are optimal for performance. Second, limiting exposure and accessibility allows one to go "off stage" and is hence useful for impression management. A person who is tired, angry, or depressed needn't make a bad impression on others or

create interpersonal tensions if he or she can temporarily retreat to private living quarters. Finally, two or more people who limit their contact with the remaining members of the group are free to engage in "limited and protected communication," that is, to interact in an open and candid manner without the need to reckon with potentially adverse reactions from the remainder of the group.

2. Privacy, Territory, and Personal Space

Territories, in part, are spatial areas which are more accessible to some individuals than to others. Territories may be public, semi-public, or private. For example, ward rooms and transit areas which are accessible to all crewmembers would be public territories; the cockpit or other specialized work areas which are open to some but not all crewmembers would be semi-public territories, and sleeping areas assigned to specific individuals would be private territories. Territories are places or locations with clear architectural or geographical referents. Personal space refers to a spatial area which surrounds the individual and which provides an invisible barrier against social intrusion. Personal space has personal, rather than architectural or geographical referents. It is compared to an "aura" or "bubble" that the person carries around from place to place.

Studies of the shape and dimensions of personal space lead to four important conclusions. (1) Personal space varies as a function of individual differences; any two people are unlikely to have identical personal space requirements. (2) Personal space also varies as a function of the situation; any individual's personal space is likely to expand or shrink as he or she changes environments or activities. (3) Although personal space surrounds the individual, it does not necessarily center on that individual. The distance that personal space extends outward from a person depends upon such factors as the horizontal and vertical angles relative to that person's front - and - center. (4) Personal space is three dimensional, in that it extends above as well as around the individual. (5) Increased personal space allowance in one dimension (for example, headroom) can reduce personal space needs along another dimension (for example, floor space).

3. Factors Affecting Needs for Privacy and Personal Space

Environmental factors, personal factors, and social factors affect desired levels of exposure and accessibility and the shape and dimensions of personal space. First, environments which actually lack spaciousness or which give the impression of being small tend to accentuate peoples' needs to limit their contacts with each other. Second, many studies have examined the effects of group and individual differences. No reliable sex differences have been obtained. Age differences exist, but since these

differences are between adults and children, they are inconsequential for present-day spaceflight planning. Cultural differences occur, and are important, given the intention to staff Space Station with an international crew. With respect to personality factors, expectations are important; people who realize that an environment is likely to be cramped or crowded are more likely to accept relatively high levels of exposure and accessibility than are people who falsely anticipate plenty of living area. Finally, social factors are important. Groups that are composed in such a way that their members' personal interests and needs complement or mesh with one another better survive isolation and confinement than do groups whose members are characterized by incompatible needs. Social standards or norms which promote a high degree of interpersonal accommodation can reduce reduce tendencies to restrict contact. Groups that are characterized at the outset by friendly interpersonal relations can better withstand isolation and confinement than can groups that begin the confinement period with tensions and hostilities.

4. Privacy in Spaceflight Environments

People's attempts to regulate their contacts with one another have been noted in all groups studied thusfar and there is no reason to expect that spacecrews will provide an exception. Needs to regulate interpersonal contact are more likely to be exacerbated than ameliorated by spaceflight conditions. First, Space Station crewmembers will be subjected to heavy work demands; limiting accessibility to fellow crewmembers will help prevent input overload and will promote rest and recuperation. Second, the multiple stresses associated with isolation, confinement, deprivation, and risk can yield potentially adverse psychological and interpersonal consequences. The opportunity to "get off stage" in order to protect the image presented to other people (and also ones views of oneself) may therefore be more important under spaceflight conditions than under many other conditions. Third, limited and protected communication may be very difficult in space, in part because of the close confinement with other group members, and in part because of the external surveillance by mission control personnel.

B. INTERPERSONAL DISTANCING

Intepersonal distancing activities are intended to increase or decrease exposure and accessibility. They serve to align the achieved and desired levels of contact, and can thereby prevent loneliness and crowding.

1. Interpersonal Distancing Mechanisms

It is convenient to distinguish among three types of interpersonal distancing mechanisms or tactics. Person - environment mechanisms involve the use of space and architecture. Examples include increasing or decreasing the physical distance

from other people, or the interpositioning or removal of doors, walls, and other archictectural barriers. Psychological mechanisms fall into two groups. Fight responses are negatively - toned verbal and nonverbal displays which encourage avoidance behaviors on the part of potential intruders. Flight responses consist of retreating from the situation: for example, turning away from the other person, or closing one's eyes and pretending to go to sleep. Social normative mechanisms involve social standards or rules that specify appropriate levels of exposure and access under prescribed conditions.

2. Interpersonal Distancing in Space

Even as isolation, confinement, and other spaceflight conditions may augment people's needs to regulate contact with one another, they may also compromise the effectiveness of the interpersonal distancing tactics that work so well in most nonspaceflight environments. Aboard spacecraft, volume and weight restrictions limit the amount of physical distance that can be achieved between two people, and also limit the availability of walls and other architectural barriers. Physical distancing is further complicated by the conditions of weightlessness; little or nothing is known about interpersonal distancing when people are free to move "up and down" as well as "around." Psychological distancing mechanisms are also undermined by the spaceflight environment. Normal fight and flight tendencies might be suppressed because they could somehow hint of maladjustment or a poor attitude. Psychological mechanisms are often based on communication; both verbal and nonverbal communication may be degraded in space, the former due to atmospheric conditions and ambient noise levels, and the latter due to weightlessness. Finally, spacecraft environments are relatively new and emerging environments, and there has not been much time for appropriate distancing norms to evolve. Old customs and conventions that are useful on earth may or may not be equally valuable under spaceflight conditions.

C. LONELINESS AND CROWDING

As noted, loneliness occurs when the achieved level of contact falls below the desired level of contact and crowding exists when the achieved level of contact surpasses the mark. Both loneliness and crowding can pose problems for spacefarers, but crowding is considered the greater threat in spaceflight and spaceflight - analagous settings.

1. Density and Crowding

A basic paradigm in studies of crowding is to vary social density (either by holding space constant and varying the number of people present, or by holding the number of people constant and varying the total amount of space) and then to assess physiological, psychological, social, and performance consequences. To understand the potentially conflicting findings

of many of these studies, it must be recognized that although high density may be a precondition for crowding, its ultimate effects depend on a sequence of events:

First, density is a physical concept, and crowding is a psychological concept. Perceptual and judgmental factors determine whether or not a certain level of social density is experienced as crowded.

Next, after a setting is defined as crowded, the perceiver initiates interpersonal distancing behaviors tactics which are intended to reduce the crowding. exposure and accessibility. These efforts can yield one of two outcomes:

a. If the interpersonal distancing attempts are effective, and the perception of crowding is abandoned, the matter is essentially brought to an end with no adverse effects.

b. If the interpersonal distancing attempts fail, and the perception of crowding is sustained, the person is subjected to stress. It is under this senario that adverse effects become likely.

2. The Effects of Crowding

The stress associated with the perception of crowding and the failure of interpersonal distancing is reflected in three types of effects. First, there are biological (or, more precisely, psychophysiological) effects, including increased heart rate, hightened blood pressure, increased palmar sweat, and the secretion of stress-related substances into the bloodstream and urine. Second, there are psychological effects which may include decreased ability to focus or concentrate, motivational decline, anger and depression, stubbornness, and negativisitic attitudes. Third, there are social effects which include withdrawal, irritability, and social conflict.

The overall impact of crowding on performance depends in part on the nature of the task to be performed. Performance decrements are more likely in the case of tasks which are poorly learned or involve complex sequences of cognitive and motor activities, than in the case of tasks which are well learned or which involve simple sequences of motor activities. Even when crowding is not evidenced in obvious work inefficiencies and errors, it may be evidenced in absenteeism, turnover, and other undesirable withdrawal behavior.

3. Crowding in Spaceflight Environments

Crowding has long been recognized as a major potential hazard for isolated and confined groups. Observers of inhabitants of spaceflight and spaceflight environments, and in some cases the inhabitants themselves, have noted occasions where crowding has impacted psychological and social well-being and performance. Crowding is a problem in its own right, because it undermines the quality of life. However, since many of the flight operations, scientific, and manufacturing tasks required to maximize the benefits of the Space Station are likely to require concentration and problem solving, crowding is also important because it is a potential threat to productivity.

II. A MODEL OF PRIVACY AND INTERPERSONAL DISTANCING

The second aim of the present research project is to develop a quantitative model of privacy and interpersonal distancing. In this section, we attempt to develop this model. By a quantitative model, we mean a model that can allow us to identify mathematical rules for expressing the functional relationships among key variables. We seek a useful heuristic model with clear design implications rather than a highly formal theoretical model.

A. CRITERIA

Ideally, the model will satisfy several criteria. (1) The model should provide for sensible and valid operational definitions of all key terms including accessibility, interpersonal distancing, loneliness, and crowding. (2) The model should allow for the mathematical expression of of all key variables, that is, recognize that these variables can assume many different values. (3) The model should identify the mathematical functions that express the relationships among the key variables. (4) The model should be consistent with reliable findings in the areas of privacy, interpersonal distancing, loneliness, and crowding. (5) The model should be practical in that it gives rise to workable suggestions for accommodating privacy needs and interpersonal distancing behaviors aboard the Space Station.

B. BASIC CONCEPT

The flow of information from one person to another provides the key to the present model. Two aspects of information flow need to be emphasized at the outset.

First, the information imparted by social stimuli usually flows in two directions. In essence, each person may be viewed as both a "transmitter" and a "receiver". We present information about ourselves to other people (exposure) and we receive information about other people that is presented to ourselves (access). Exposure and access are typicaly correlated with one

another, but they are not invariably in balance: for example, a crew that is under video surveillance by mission control but which cannot itself view personnel at Houston is in a relationship characterized by high exposure but low access.

Second, the information that flows from person to person can flows along four different sensory "channels" which we describe in terms of vision, hearing, smell, and touch. Vision inputs information about physical appearance, and is also proxemic information (regarding the other person's location in physical space) and kinesic information (regarding the other person's postures, gestures, and facial expressions). Hearing provides for the receipt of linguistic information (what is said) and paralinguistic information (how it is said). Although rarely discussed, smell or olfaction makes it possible to detect other people's perfumes, body odors, and other scents. Smell is important in the present context because limited hygenic facilities may give rise to concerns about exposure through body odor. Finally, at close range, people can communicate through touch.

C. INFORMATION FLOW, PRIVACY, AND INTERPERSONAL DISTANCING

The basic terms, concepts, and findings presented in the introduction to this report can be understood in terms of rate of information flow. For example, each of the three major functions of privacy can be understood in terms of regulating the flow of incoming or outgoing information. The arousal reduction function performed by decreasing interpersonal contact can be viewed in terms of preventing excessive incoming information, that is, preventing information input overload. The self management function of privacy can be viewed as a problem of controlling exposure, that is, the information presented to others about the self. Limited and protected communication can be viewed as a case of high information flow between the members of a small group coupled with restricted information flow between the members of that group and a larger social entity.

Interpersonal distancing mechanisms are in the service of regulating information flow. Specifically, increasing physical distance, interpositioning barriers between the self and another person, turning away from another person, or simply "clamming up" in that person's presence reduces communication. Loneliness occurs when there is inadequate information flow; that is, when the rate of information flowing between two people is less than the amount of information sought. Crowding occurs when there is an exessive rate of information flow. As open systems theorists note, information input overload increases inefficiencies and errors and causes wear - and - tear on the organism.

D. SPECIFICATION OF VARIABLES

Social signal strength refers to rate of flow of information from one person to another. Exposure signal strength refers to the visual, auditory, olfactory, and tactile information emitted from the self to the other person. Access signal strength refers to the visual, auditory, olfactory, and tactile information displayed by another person to the self.

Social signal strength is strong to the extent that (1) multiple channels are involved (sight, sound, smell, and touch); (2) the signal passes a short distance between the transmitter or "emitter" and the receiver; and (3) competing signals are weak. Conversely, a restricted number of channels, increased distances, and the presence of strong competing signals or "noise" decrease social signal strength.

Privacy refers to the extent to which the achieved level of exposure (exposure signal strength) and the achieved level of access (access signal strength) align with desired exposure and access signal strengths. Loneliness, of course, occurs in the case of insufficient signal strength, and crowding in the case of excessive signal strength.

Interpersonal distancing involves varying exposure and access signal strength. Maximum distance and minimum signal strength occur under conditions of solitude in a secure, sound - proofed room that contains no trace of previous occupants. Minimum distance and maximum signal strength occur under conditions of close physical contact. Signal strength variations between the two extremes depend upon the attenuation of signal strength through proxemics, filters, blocks, illusory barriers, and distractors.

Proxemics in this context refers to the physical distance between two people and their angle of orientation relative to one another. As physical distance between the two people decreases, and as their orientation to each other approaches head-on (0 - degrees), each person occupies a greater portion of the other person's visual field, with the result that there is high resolution of facial features, expressions, and other visual cues. Each person's voice becomes increasingly loud and clear to the other, and, as distances further diminish, scents can be detected and touching can occur. Additionally, since decreasing distances result in the two people occupying increasingly greater portions of each other's perceptual field, potentially distracting signals become overpowered or crowded - out. Increasing distance, on the other hand, decreases both exposure and access. A change in the one person's angle of orientation vis - a vis the other can also produce this effect; however, turning away from another person is likely to reduce access more than exposure.

Filters refer to environmental features and psychological processes which reduce social signal strength by impairing the rate of flow of some, but not all, of the information that is flowing along a given channel. For example, poor illumination may obscure facial features (thereby filtering out the information contained in facial features) while leaving posture, at least in silhouette form, in full view.

Blocks refer to features which effectively eliminate all information of a particular type. For example, doors and walls and other architectural barriers can completely eliminate visual exposure and access. Similarly, one-way video from a spacecraft to the ground leaves the crewmembers with high visual exposure but blocked visual access.

Illusory barriers perceptually, rather than physically, separate people from one another. Illusory barriers include personal possessions used as visual "markers" to delineate personal space or to define a territory. An example of the former would be personal effects spread on a table intended to accommodate more than one user; an example of the latter would be the use of photos, posters, and other personal memorabilia to personalize an area near a dormitory bunk. Whereas illusory barriers do not impede light, sound, and so forth (as would be true in the case of nonillusory barriers such as filters and blocks) they serve as psychological deterrents to potential intruders and in this manner reduce social signal strength.

Distractors refer to nonsocial stimuli which potentially interfere with social inputs. They include interesting windows, works of art, television shows, reading materials, and the like, that provide alternatives to social interaction.

E. RELATIONSHIPS AMONG VARIABLES

An ideal model of privacy and interpersonal distancing would address two basic questions:

1. What are the determinants of desired levels of exposure and access ?

2. What are the determinants of achieved levels of exposure and access ?

From a theoretical view, both of these questions are important, but from a practical view, it is the second of these questions that deserves the closest attention. Given that the Space Station will be staffed with a large number of different people over successive missions, that these crewmembers will represent a variety of backgrounds and interests, and that they will be confronted over time with a wide range of needs, conditions, and situations, we can expect, overall, a very wide range of exposure

and access needs. From a practical point of view, this range is more important than any central tendency within the range. Even as the "average" amount of stress on a bridge is inconsequential relative to the maximum stress during rush hour, average exposure and access needs are less important than minimum and maximum needs.

The Space Station should be designed in such a way as to allow for both as much and as little exposure and accessibility as is consistent with weight and volume restrictions. Then, the overriding question becomes how to provide inhabitants with the means for achieving the levels of exposure and access that they seek. The present model focuses on this latter question, and seeks to explain how proxemics, filters, blocks, illusory barriers, and distractors affect achieved social signal strength.

III. RECOMMENDATIONS

Our practical suggestions for how Space Station inhabitants can meet their changing privacy needs fall into six categories. Here, we briefly describe each category and offer sample examples.

A. MAXIMIZATION OF ACTUAL SPACE

The maximization of actual or real interior space increases the lattitude for two people to vary their physical distance and in this way to regulate exposure and access. Example: the use of a pocket door to prevent wasting the space required by a hinged door's arc increases the space available for physical distancing.

B. MAXIMIZATION OF PERCEIVED SPACE

The maximization of perceived space has been found to alleviate the perception of crowding and its associated stress. Colors, illumination levels, and other cues that give the impression of spaciousness enhance the perceived relative size of the "ground" or environment against which the "figure" or person appears. In terms of the proposed information flow model, the same environmental attributes that enhance perceived spaciousness increase the ratio of noise relative to social signal strength. Example: relatively light interior colors lead to increased impressions of spaciousness and decreased feelings of crowding.

C. CREATIVE USE OF FILTERS AND BLOCKS

Architectural and other features which attenuate, mask, or completely block verbal or nonverbal communication (including communication through smell and touch) reduce social signal strength. Example: the use of speaker grille cloth walls between work stations would reduce visual contact and exposure while leaving verbal exposure and access in tact.

D. ILLUSORY BARRIERS

Design features that appear to set a person off from the rest of the group can effectively reduce the information flow between that person and the rest of the group. Example: two people can engage in limited and protected communication in a darkened corner of an otherwise well - illuminated room.

E. DISTRACTORS

The availability of interesting individual activities, complex visual patterns provided by pictures, video displays, and windows, and so forth, provide the opportunity for varying the ratio of non-social to social signals and can therefore affect exposure and accessibility. Example: the use of personal high - fidelity cassette recorders which provide music as an alternative to conversation.

F. NON-DESIGN RECOMMENDATIONS

The focus of this report is the use of architectural and other design features for regulating exposure and access. However, there are other steps which can serve these same ends.

Personnel selection techniques could include measures of candidates' exposure and access needs. They could also involve assembling crews whose needs and interests are such that they are likely to get along well under conditions of high exposure and access.

Training can promote realistic expectations regarding exposure and access in a spacecraft environment. Training in interpersonal relations reduces conflict and thus raises tolerance for high levels of exposure and access.

Group norms which help people develop and defend modest territories or "turfs" have been found to increase tolerance for isolated and confined settings. Steps can be taken to promote functional and privacy and distancing norms aboard the Space Station.

To summarize the thrust of our efforts, the Space Sation as presently envisioned is likely to include provision for relatively low levels of exposure and access (for example, individual sleeping compartments), and also for very high levels of exposure and access (for example, a ward room). Given the maximum range of degrees of privacy that the Space Station can accommodate, the question becomes how to increase the number of utilizable gradations, that is, the practical range of values that exposure and access can assume. The problem is a relatively simple one in normal settings where large spatial areas are possibilities and where there are few constraints against

constructing many rooms of many sizes. But in the case of Space Station, volume and weight restrictions eliminate the options available to planners of hotels and convention centers. Our theme is that it does not require large areas and a multitude of walls and doors to accommodate an array of exposure and access needs. The careful planning of the hard architectural features; the use of lightweight "soft" features (screens, movable partitions, and so forth); the availability of small personal items that can be used to stake-out territories; the creative use of decor variables such as color and light; and the recognition of possibilities in such areas as selection, training, and social organization can promote a wide range of exposure and accessibility options despite severe volumetric limitations.

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